World's Largest Biogas-Powered Fuel Cell

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Concept

Combustion Chemistry without the Flame

Fuel cells produce electricity by combining hydrogen and oxygen to form water. Since hydrogen does not exist on earth in elemental form, it must be manufactured, typically from fossil fuels. By separating the combustion reaction into two steps, fuel cells generate fewer byproduct emissions and produce electricity more efficiently than traditional power generating equipment.

Teamed with USEPA and FuelCell Energy, King County (Seattle metropolitan area) installed a molten carbonate fuel cell in its South Treatment Plant. Connected to the plant's digester gas system, the fuel cell began operation in June 2004. At Year 1 of the two-year demonstration period, *project objectives* have been met:

- Demonstrate molten carbonate technology on digester gas
- Generate nominal 1 MW (net AC) with both natural and digester gas

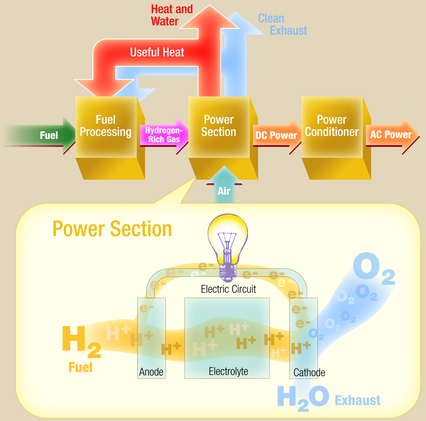
During Year 2, a waste heat recovery system will be tested in an attempt to raise the overall thermal efficiency. The recovered heat will be returned to the digesters. Additionally, treatment plant staff will continue to gain experience operating the fuel cell. King County plans to continue operating the fuel cell beyond the demonstration period.

Follow our progress at
http://dnr.metrokc.gov/wtd/fuelcell

$H_2 + 1/2O_2 \rightarrow H_2O$ (4x) (FUEL CELL)

$CH_4 + 2H_2O \rightarrow CO_2 + 4H_2$ (REFORMER)

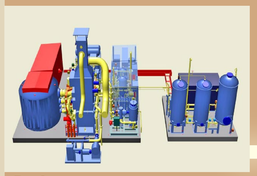
$CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$ (COMBUSTION)



Molten Carbonate Fuel Cell Diagram

Fuel cells are similar to rechargeable batteries, which are discharged and then recharged, except fuel cells require a constant fuel source (i.e., constant recharging) and continuously generate electricity. Methane, from either natural gas or digester gas, enters the fuel processing stage. The fuel is preheated, partially reformed, and then flows to the anode. The reforming reaction (hydrogen formation) is completed in the fuel cell stack. Air flows through the cathode. Hydrogen splits into electrons and protons at the anode, and the electrons leave the fuel cell. The electrons return at the cathode, react with oxygen, and form water.

Implementation


Design


Manufacturing


Factory Testing


Delivery

Operation

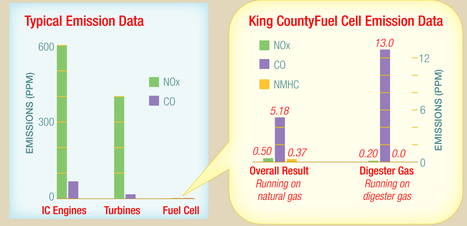
Lessons Learned

- Fuel cell performs well and operates reliably. 4.3M kWhrs of electricity generated (2.7M on NG and 1.6M on biogas) during 5,700 hours of runtime (3,600 on NG and 2,100 on biogas). Operating on natural gas, the fuel cell 96% available; on digester gas, 83% available.
- Permitting efforts mixed. Building and air permits easily obtained but electrical permit and interconnect agreement required considerable time and energy.
- Fuel cell is sensitive to gas quality. Spikes in methane content are the main reason for shutdowns.
- Capital cost is decreasing, but still high relative to traditional power generating technologies. Total budget for project approximately $22.8 million ($12.5M USEPA, $9.4M FCE, $0.9M KC). Subsidies and regulatory drivers are currently required to make fuel cell technology cost effective. Even with the cost hurdle, worldwide fuel cell sales are growing.

Performance

Emissions

- Emission data demonstrate lower NOx, CO, and VOC concentrations.
- No VOCs were detected while operating on digester gas.
- Methane breakthrough did occur, ~250 ppm for natural gas and ~290 ppm for digester gas.



Efficiency

- The fuel cell operates at higher efficiencies. Current electrical efficiency is approximately 43%.
- Operation of the waste heat recovery system will capture 1.7 MMBtu/hr, raising the thermal efficiency to approximately 65%.